AD-A046 058 RAYTHEON CO WALTHAM MASS MICROWAVE AND POWER TUBE DIV F/G 9/1
HIGH POWER, FLUID COOLED HELIX TWT.(U)
JUL 77 N00173-76-C-0354
UNCLASSIFIED PT-5047 NL

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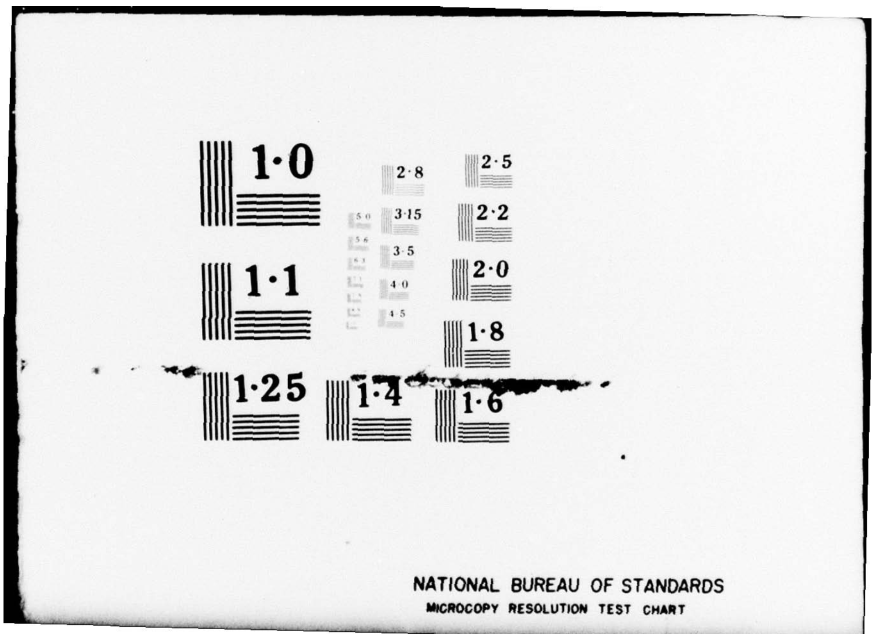
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

AD A 046058

NRL #530647

(2)

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RAYTHEON COMPANY
Microwave and Power Tube Division
Waltham, Massachusetts

(6)

HIGH POWER, FLUID COOLED HELIX TWT.

(9) QUARTERLY PROGRESS REPORT NO. 3, 1 Apr.-30 Jun 77.

(15)

Contract N00173-76-C-0354

Data Item A002

Period Covering 4/1/77 to 6/30/77



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NAVAL RESEARCH LABORATORY



(14)

PT-5047

(11) 13 July 1977

(12) 10 p.



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## 1.0 INTRODUCTION

The objective of this 3 phase program is to develop and perfect a fluid cooled helix technology, including the development of full-duty electron guns and beam design. The primary hardware to be delivered are engineering models of an L-band, high-power, fluid cooled helix TWT that may become the prototype for an advanced Navy shipboard radar system. The frequency coverage and output power of the fluid cooled helix TWT will be such as to replace two TWT amplifiers of the ring-bar type. The design goals for this TWT are shown in the following chart.

MAJOR DESIGN GOALS

| | |
|---|---|
| Frequency Range | .85 - 1.4 GHz |
| Peak Power | 250 kW min; 320 kW goal |
| Beam Voltage | 35 - 45 kV (40 kV design goal) |
| Duty Cycle | 6% |
| Gain | 30 dB min. |
| Life | 10,000 hours |
| Focusing | Fluid Cooled Solenoid |

The specific objectives of Phase I of this program (covering the period of 10-76 to 4-78) are a) to design and develop a reliable beam optical system, focusing mechanism and suitable collector for a high power, high perveance, broadband TWT, b) to deliver one beam tester suitable for design evaluation and initial systems modulator testing, and c) to carry out sufficient cold test measurements to design a suitable output coupler with fluid adapter, rf structure, and cooling mechanism for use in the engineering models to be built in Phase II.

## 2.0 TECHNICAL DISCUSSION

### 2.1 Change of Program Plan

A meeting was held in April with representatives of both NRL and Raytheon. At that time, the decision was made to stop work on the

Fluid Cooled Helix TWT until Raytheon completed a 40 kV, high perveance gun design. This study required an estimated three and one-half months to complete and would result in a corresponding delay in the remainder of the schedule. After the study is completed, another design review will be held to decide the perveance of the final gun for the Fluid Cooled Helix TWT.

### 2.2 Gun Design

In mid-April, the design work for the 40 kV gun began using Raytheon's Kirstein-Hornsby (HKMAG) computer program. Twenty runs were made and a preliminary design was reached. However, the limits of the accuracy of HKMAG had been reached. Further attempts to improve the gun design resulted in the program predicting erroneous data or incurring convergence problems. At this point, it was decided that the gun design could be optimized on Raytheon's new deformable mesh computer program. However, due to legal delays in procurement and problems getting the program on-line and operational, the program was not available until the end of June. At this time, the last successful run from the Kirstein-Hornsby program has been duplicated on the deformable mesh program so optimization of the gun design can now begin. In order to make up some of the lost time, Raytheon plans to work during part of its three week shut-down.

A copy of the present status of the gun design is shown in Appendix I. The ray traces show clearly that the design needs improvement to reduce the unusual charge destribution at the beam waist and to minimize ray cross-overs. It is anticipated, that minor adjustments in the cathode spherical radius, the focus electrode shape, and the anode to cathode spacing will produce a well behaved beam.

### 2.3 Backward Wave Oscillation Analysis

Once the decision was made to proceed with the 40 kV gun design, some additional small signal runs were made to determine whether a sufficient amount of safety had been built into the rf design to prevent backward wave oscillations in the output section of the tube. These runs were based on the following data: $V_p/c(FW) = .2524$, $V_p/c(BW) = .2673$, $K_{-1}(\text{on axis}) = 1.04\,\Omega$, $r_b = .250$ inch, Fill Factor = 50%

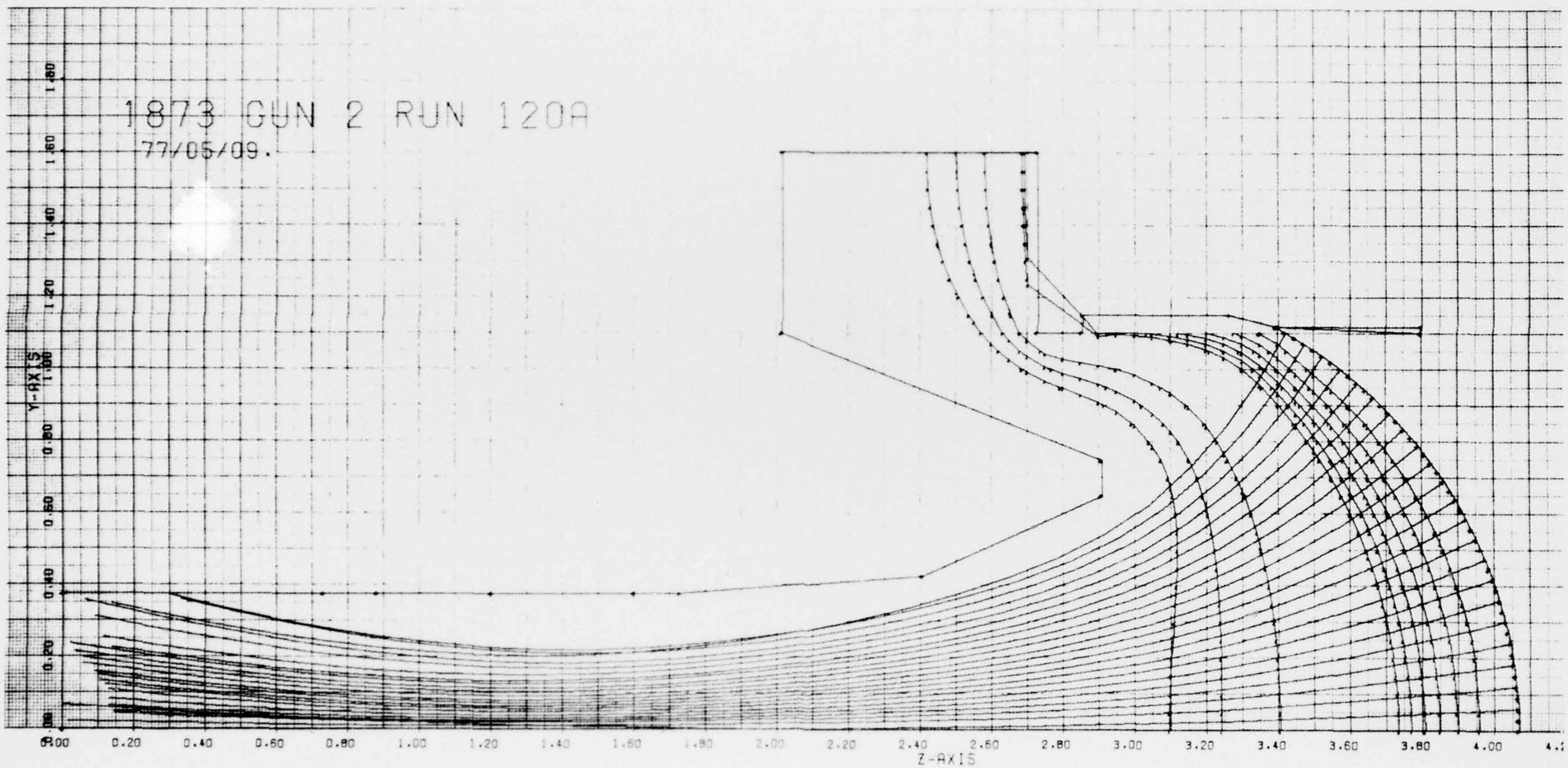
The output section consists of two parts - one cooled by water flowing through the ceramic support stubs, and the second cooled by water flowing axially down the helix structure. The first section, about 15" in length, has water present in the rf field. Due to the measured selective loss characteristics published by NRL and verified again at Raytheon, the lossy characteristics of water near the BWO frequency are such as to insure that no BWO can occur in this region.

In the second section, about 10" in length, there is no water in the rf field region to attenuate the growth of the backward wave. Raytheon's small signal computer program analyzed the second section of the output and predicts that the output will be stable as long as the length of the second section does not exceed 17". Hence, there is a 7" "safety factor" built into this part of the design to insure that no backward wave oscillations can occur.

2.4 Stress Analysis

In the previous monthly report, the results of the Raytheon SAAS3 (finite element structural analysis) computer program were briefly presented to show the structural integrity of the ceramic to metal braze on the helix support stubes. Since only raw data was available, only a qualitative report was made, indicating that the braze was "safe" and "that no yielding takes place during operation between -50°C and +100°C". The computer graphics to quantitatively verify these statements are shown in Appendix II. The first graph shows a rectangular cross-section of the ceramic to metal joint with the distortion due to brazing expanded 10X. The horizontal axis is the "r" axis, the vertical axis the "Z" axis and normal to the page is the "$\Theta$" axis (in regular cylindrical coordinates where the "Z" axis is the centerline of the support stub). The second graph shows the principal stresses (Sigma-Max) in both the ceramic and the cupronickel support. The maximum stress in the graph is just over 30,000 PSI in the alumina and about 60,000 PSI in the cupronickel. Although 30,000 PSI is at the upper edge of the safety limits for alumina, the model does not taken into account the solder fillet which will occur at the square corner. Since the maximum stress is exactly located at the square corner, the real stress will be less than 30,000 PSI. The final graph shows the principal strains since they are less than .1% (in inches/inch), they can be ignored.

# APPENDIX I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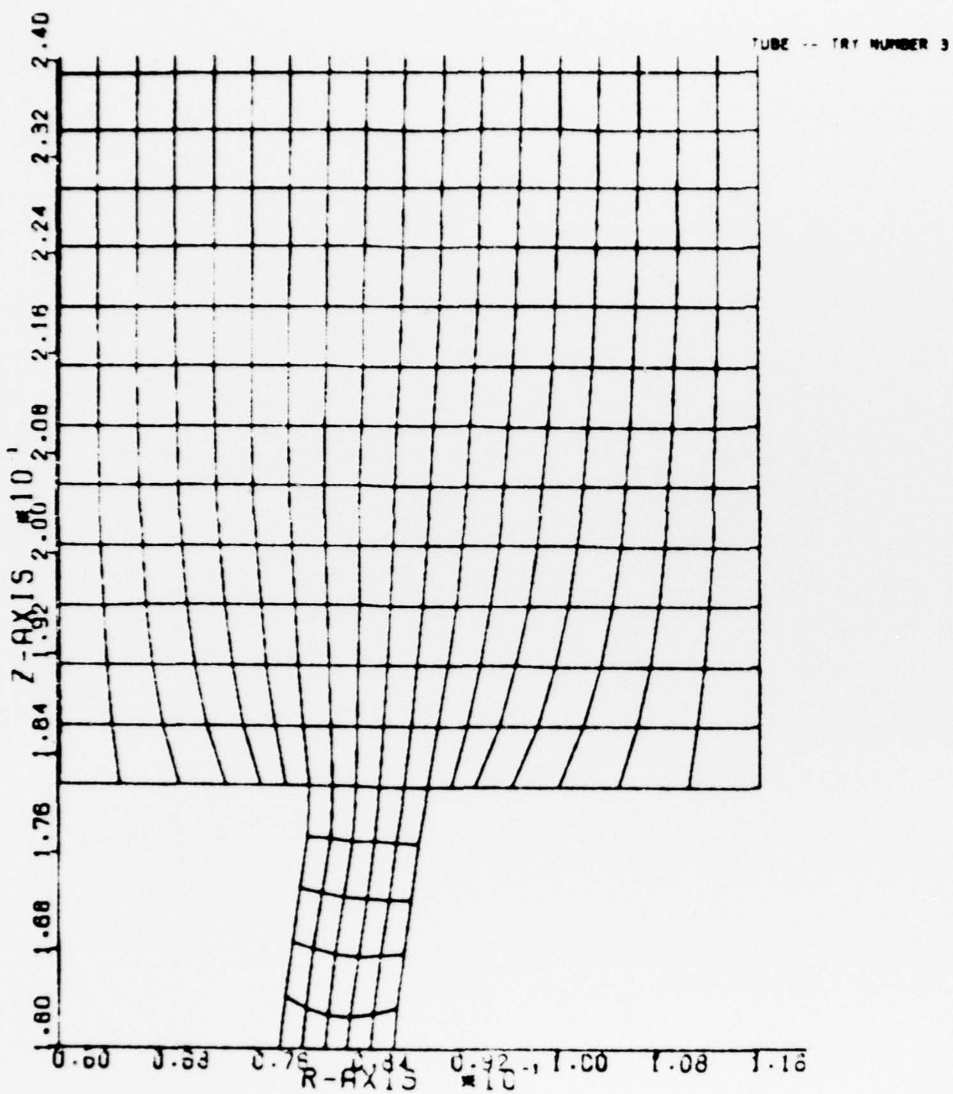
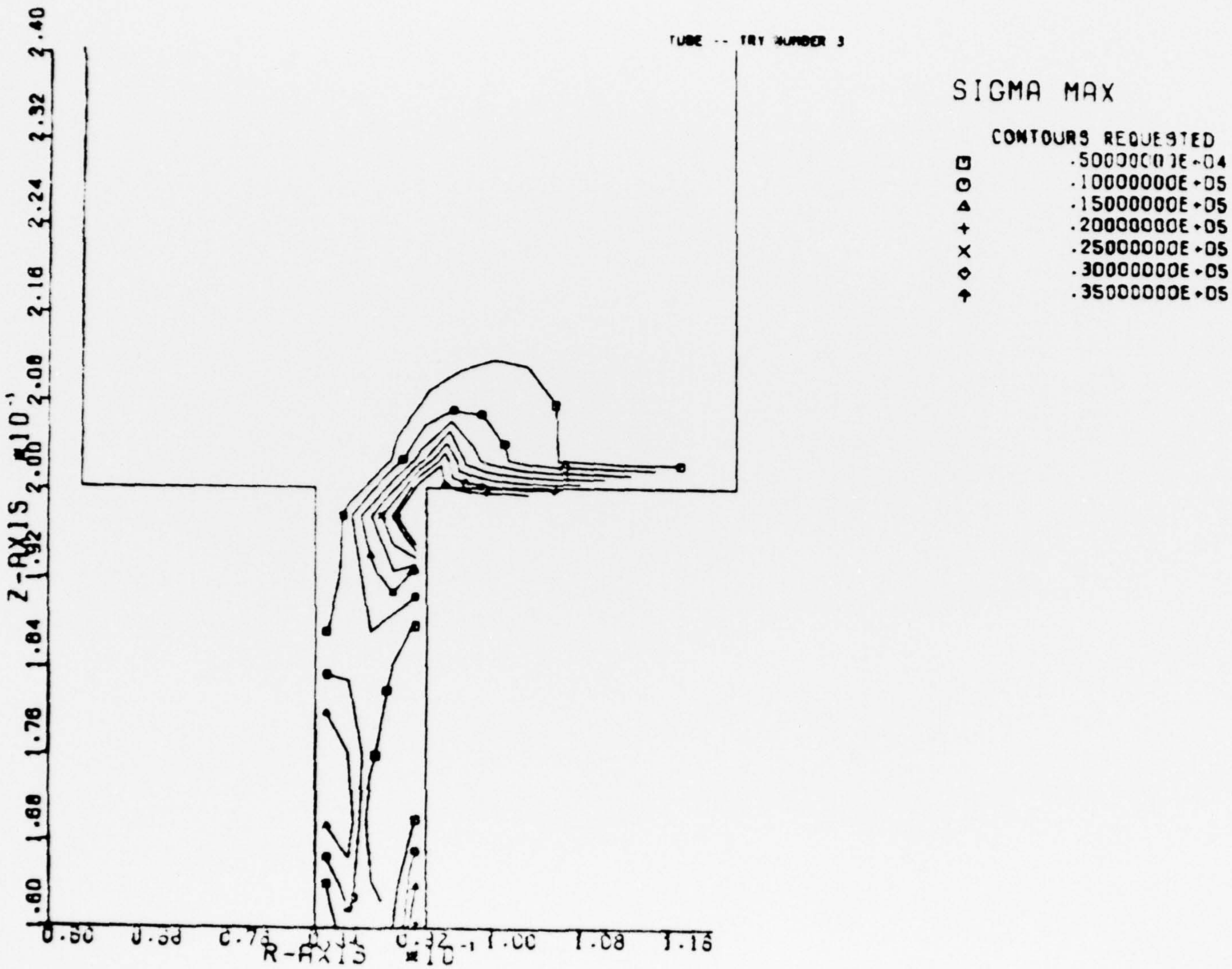
4.00

# APPENDIX II




DEFORMED ELEMENT PLOT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.35000000E+05
Z-AXIS
R-AXIS
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1.68
1.76
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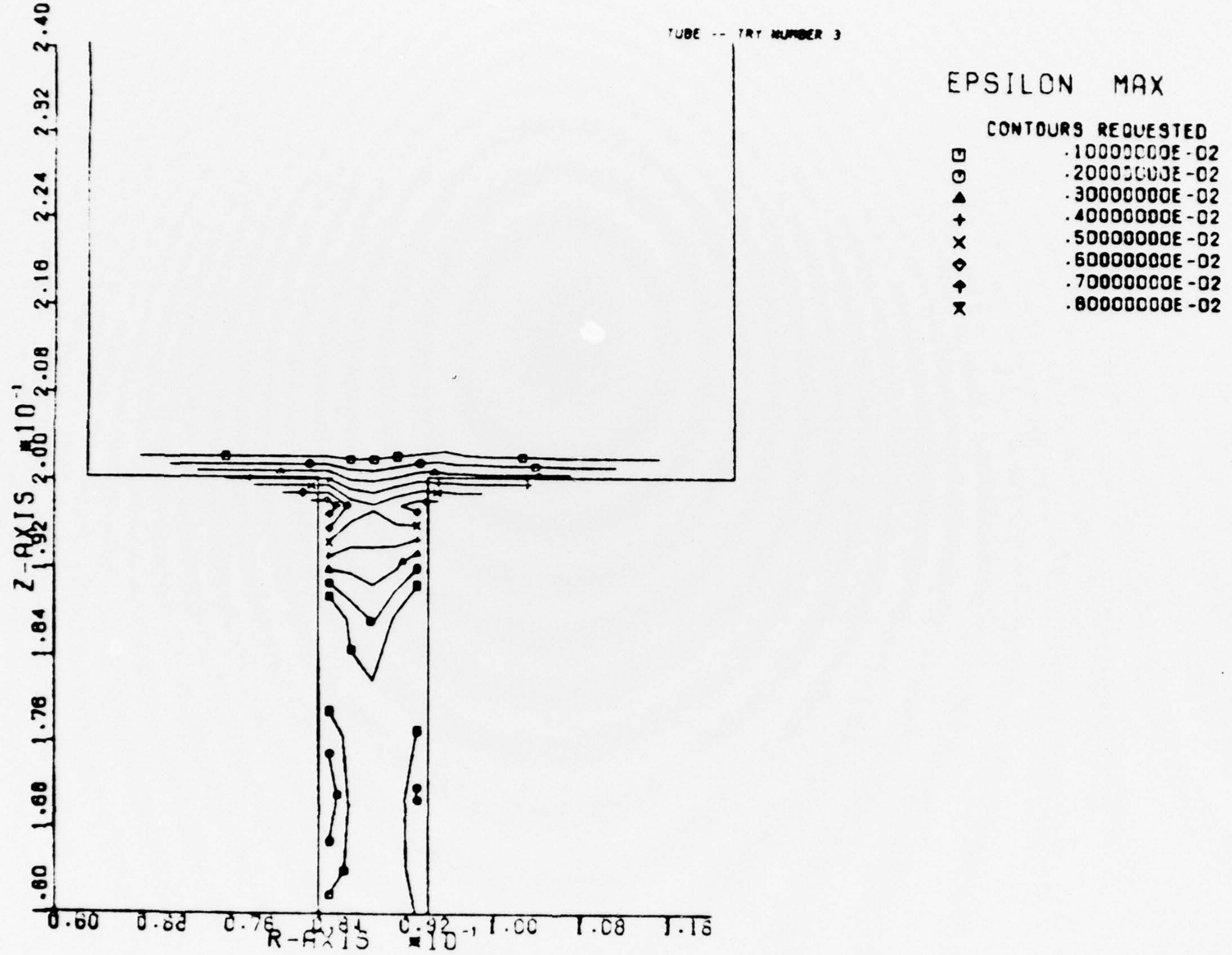
1.16



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.80000000E-02
Z-AXIS ×10⁻¹
R-AXIS ×10⁻¹